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The Cost/Benefit of Aging on Safety and Mission Completion in Aviation Professions

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Summary:

The suspected detrimental effects of aging lead to concerns about aging pilots in civilian and, to a lesser extent, military flying. The typically superior cognitive ability of all pilots, and experience of older pilots in particular, however, render them a valuable asset and dictate they be carefully assessed when concerns about their cognitive ability arise.

Main Body:

Pilots face many environmental stressors, such as acceleration, vibration, noise, and elevated altitudes with attendant reduced oxygen. Other challenges, particularly faced by military pilots, include: Performing while fatigued, flying across time zones producing circadian desynchrony, and being expected to be perpetually prepared to potentially engage in combat. While potential for performance (aptitude) fades with increasing age after an initial peak, the increased experience concomitant with aging serves to hone some abilities. While this paradox is true of all individuals, the complex and demanding environment inherent in aviation presents particular challenges. Nowhere is this paradox more apparent than in aerospace medicine. Aging aircrew present a diagnostic dilemma when they present themselves for aeromedical evaluation: It is counterproductive and misleading to compare certified possessors of the "right stuff" to their age cohorts in the general population when performing neuropsychological evaluations. An examiner needs a suitable reference group for appropriate norms. These norms, however, have traditionally not been readily available. The recent return of Senator John Glenn to space in his 78th year is a vivid example of the durability of the right stuff.

Neuropsychological findings based on the general population can only be generalized to the rarified sample of aviators with great caution, if at all. During a study supported by the Defense Women's Health Research Program, we tested 46 USAF female pilots (mean age 30) and 64 male USAF male pilots (mean age 29) and found the following:

Table 1. IQs of 110 experienced, nonreferred pilots

	Mean	Standard Deviation
Verbal IQ	120.36	5.57
Performance IQ	122.21	7.18
Full Scale IQ	122.95	5.35

While these levels of intelligence are striking and within the superior range of intellectual functioning, the standard deviations are of particular interest. While the general population has an average IQ of 100, the standard deviation is 15. These standard deviations suggest that this is a homogenous group. Other studies have reported similar results (5, 6, 22). IQs are calculated with reference to a cohort group clustered in age increments. Therefore, differential exposure to experiences and information, as well as physiological decline, is factored into each grouping. These results represent only a snapshot in time and do not address the possibility of future differential reduction in functioning. These individuals were either directly or at least indirectly selected to be pilots based on their extraordinary intellectual abilities (5). We don't know how well these extraordinary abilities are retained over the course of a lifetime, particularly when confronted with the stressors inherent in aviation, enumerated above.

While there may be times of increased vulnerability for (civilian) accidents at certain experience levels

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("around the 100 hour mark;" 20, p. 17; "between 100 and 300 hours total;" 12, p. 101), this factor is due more to experience than age. It is important to tease out the highly confounded effects of experience when considering aging (and vice versa). Eyraud and Borowsky (4), in a five-year study of US Naval pilots between 22 and 40, found that older, and hence probably more experienced, pilots had fewer mishaps. Of the accidents the older pilots had, they were due to procedural errors and violations of regulations. These violations of regulations suggest the possibility of overconfidence in the older Naval pilots.

We know a good deal about aviators who experience accidents, we do not know as much about aviators who do *not* experience accidents. It may be somewhat useful to calculate rates, based on gender and age groupings, bearing in mind the differential risk each group is likely to face. For example, younger pilots have exposure to risk as they are more likely to be represented in the "student" category, but experienced aviators are given the riskiest missions. Also, researchers need to adjust their data based on accidents per hours flown, while considering the level of risk of the mission.

In many ways, the medical concern over aging pilots is much less urgent in the active duty military than in commercial aviation. Active duty military pilots are range restricted in term of age. The military services of the US have age limits of when candidates may enter initial flying training; the youngest age possible is limited by the need for a college degree (placing a lower limit of approximately 21 or 22 years of age). The upper age limit in the USAF has typically been between 26½ and 27½ years of age at entry into flying training, with waivers up to age 30 possible. These waivers have been typically liberally granted. For instance, in 1998, 141 age waiver requests were processed, with 98 percent approved, producing an age range of those with age waivers from 27 years, 7 months to 30 years, 11 months. The other US services are roughly similar; those with higher age limits being less liberal in their granting of waivers. Even if a pilot were to fly for the entire twenty years of their active duty military career, which is highly unlikely, they would still be far short of the magic age of 60¹. USAF pilots are expected to

perform a minimum of 10, and usually 12, years of flying plus rated staff duty that benefits from their rated experience. The issue of age restrictions in the military is not related to age, *per se*, rather the issue is return on the expensive investment of flying training. The concerns include older pilot candidates being historically less likely to complete training, ending up in jobs not commensurate with their rank when they complete training, being disadvantaged by slowed reactions and other unfavorable physiological trends, and in short, suffering from a interaction of increased age coupled with lack of experience. Pilots who were not immediately assigned to flying duties due to a shortage of available cockpits, "banked pilots," faced the same challenge of increasing age without benefit of concomitant increasing experience.

Pilots who leave active duty and opt to fly for the Guard or Reserve may remain in a military cockpit even longer than they would in a civilian cockpit, as the military has no upper age limit on performing flying duties. Of even greater concern may be the relatively limited opportunities to fly, although many of these individuals also fly commercial aircraft. Flying dissimilar aircraft, however, increases the risk of committing the error of habit interference (negative transfer). This type of error is one that is actually *more* likely as a pilot gains experience, similar to the errors of complacency and overconfidence.

Numerous studies (as cited in 17 & 24; also see 25) suggest that while reductions in some cognitive abilities in pilots are offset by greater experience, *individual* differences tend to be greater than *between-groups* differences when looking at groups of young and old aviators. Similarly, air traffic controllers are more likely to commit an en route error as they age (after age 40); increasing experience, however, mitigates this effect (Broach, 1). Broach advocates a longitudinal study as he based his conclusions on a cross-sectional study.

(FAR) Part 121 (commercial pilots carrying 10 passengers or more) mandatorily retire upon reaching age 60. The FAA has been working on a system to calculate a pilot's *functional age* to individually determine when a pilot should stop flying in the interest of safety (10). Within several years, pilots who carry *any* commercial passengers will be required to comply with the age 60 rule under FAR, Part 119.

¹ The US Federal Aviation Administration requires pilots operating under Federal Aviation Regulations

Studying age cohorts as they mature affords an opportunity to appreciate the motivation changes that impact professionals in the course of their careers. In any case, the benefits of increased experience, such as automaticity (the ability to do things without needing to think), may become overwhelmed during emergency and nonroutine situations.

What should be done when an aviator, due to a performance deficiency suspected of having a neuropsychological etiology, comes to the attention of an aeromedical examiner? For years, mass testing of applicants for pilot training was conducted with instruments from the experimental psychology arena and was specific to the branch of service developing the respective test. This technique limited the ability of the instrument to be used for later clinical assessment, if the need arose. Moreover, most clinicians are not familiar with these instruments, or at least do not know how to access an individual's results, and hence not likely to use them when conducting a clinical assessment (3). On the positive side, clinical tests are better safe guarded as they do not have guidebooks to aid test takers, at least not officially published ones, while selection tests may (see 26).

A recent example, drawn from his own account (9), is the case of aviation showman and septuagenarian Bob Hoover, who was medically grounded by the Federal Aviation Administration (FAA) due to concerns about his mental status and its impact on his ability to fly safely. His contemporary and good friend, Chuck Yeager (also in his seventies), gallantly volunteered to serve as a "comparison group" when Mr. Hoover was offered a neuropsychological evaluation. Current efforts may provide a scientific reference base for these types of cases as the Neuropsychiatry Enhanced Flight Screening program archives cognitive functioning captured at the commencement of flight training (15). This battery of tests includes two that are mandatory for every candidate entering pilot training: Multidimensional Aptitude Battery (MAB; 11) and CogScreen-Aeromedical Edition (14). The MAB is an intelligence test closely corresponding (correlation = 0.91) to the Wechsler Adult Intelligence Scale-Revised (WAIS-R), the most widely used and respected adult intelligence test in clinical practice. The MAB, similar to the WAIS-R, determines verbal, performance, and full scale intelligence quotients (IQs) by plotting obtained raw scores against norms collected for

various age groups. The CogScreen is not a test of aviation knowledge; rather it is a computerized neuropsychological screening instrument sensitive to cognitive functioning.

In addition to the obvious advantage of being able to neuropsychologically compare an individual to him- or her- self over time, such a collection of norms of high functioning individuals also provides a pool of age norms for high performance operators. Moreover, a cross-sectional comparison of fledging military aviators (mean age 23.5, $n=512$) to experienced airline pilots (mean age 44.0, $n=584$) on CogScreen clearly demonstrated the former excelling in tasks requiring cortical flexibility while the latter performs better in generic complex problem solving (2). A longitudinal study on the effects of aging on performance on CogScreen will be more meaningful as it will afford a within, as opposed to between, subjects design.

Case Vignette:

A medical doctor calls a psychologist to seek guidance about a pilot in his mid sixties. This aviator's supervisor is concerned with a recent onset of critical omissions, almost resulting in tragic consequences on more than one occasion during emergency procedures. This aviator, however, continues to successfully negotiate check rides and routine flights. The flight surgeon wants to send him to a local psychologist. You advise against this course of action due to your concern that this aviator would be compared against his age cohorts in the general population; subtle impairment in this aviator could easily go undetected. The psychologist advises referral to the tertiary facility where at least a baseline assessment could be established to gauge any dementing process.

Dissimilar to the safety consequences of cardiac disease, neuropsychological impairment is unlikely to result in sudden incapacitation. As the case vignette illustrates, neuropsychological impairment is likely to be subtle and not have a great impact on well-practiced skills. Rather, the senses, memory, reaction time, and ability to combat fatigue are likely to show the greatest decline (17).

Age is the address of where you are in life...

A person's chronological age is highly correlated with events that take place in the course of a lifetime. The lock-step structure of military career progression serves to make this even truer for military aviators. Motivation tends to change as a function of changing life circumstances (13). While middle age pilots may seem to be slowing down and may in fact be slowing down, they may also be responding to increased family responsibilities and a changes in life goals. Many may find themselves as part of the "sandwich generation" – caring for children who have not yet left home and concerned about aging parents. As increasing numbers of female pilots mature into senior aviators, it will be interesting to track their career and personal progression, which may differ markedly from their male colleagues as determined by their divergent goals (18). Moreover, female pilots have been shown to be more extroverted, agreeable, and conscientious than their male counterparts (16). While basic personality structure is unlikely to change during the course of an aviator's career, attitudes are likely to change considerably, which are directly related to performance (7). The work milieu during the course of an aviator's career changes, for example, the level of automation is steadily increasing. Those not raised using computers may be uncomfortable relying on them during flight. "With increasing cockpit automation, requirements for pilot aptitude are shifting from emphasis on 'stick-and-rudder' skills to interpersonal programming and monitoring capabilities-in short, management skills" (8, p. 488). It is therefore important to know what type of criteria was used when the pilot you are considering, from either a clinical or research perspective, were selected.

There are old pilots and there are bold pilots, but there are no old bold pilots...

Since the CogScreen is not influenced by experience in aviation and since airline pilots are largely mined from the pool of military aviators, it is reasonable to assume the differences are mostly a function of aging, with perhaps some selection and attrition influences as well. Another mitigating factor could be aircraft accidents that serve to slightly reduce the pool of aviators who go on to become civilian pilots. Such a confound is of interest for several reasons: aviators with relatively

few flying hours (who are younger) are statistically more "dangerous" than more experienced aviators. Such a state of affairs may make it possible to "prove" that female aviators are more accident prone when the reality of any increased rate of accidents may be due to their inexperience and lack of representation in the more experienced group. On the other hand, experienced aircrew are typically assigned more challenging and hazardous missions (including training fledgling aviators). We need to calculate the level of risk to appreciate the exposure faced by aviators, when determining the dangerousness of an aviator, or a group of aviators. It is unwise to simply linearly correlate age with accidents. Moreover, measuring performance by way of presence or absence of an aircraft mishap fails to recognize the low base rates of mishaps and the high prevalence of errors in all flights.

There are strategies for overcoming the detrimental effects of aging while retaining the benefits of experience. Morrow (19) argues that air traffic control messages be organized and presented in a standardized format. Furthermore, messages should contain cue words and intonation to minimize the possibility of pilots hearing what they expect to hear. The strategies to aid older pilots will aid *all* pilots.

Discussion

As the pool of available aviators decreases, aircraft become more complex, and training costs dramatically increase, better understanding of the issue of the aging aviator is paramount. Linear explanations, that do not consider level of experience and risk, have bedeviled aeromedical practitioners and researchers attempting to understand the relationship between aging and safety/mission completion. As fatigue is a bigger risk factor for older aviators, regardless of their experience level, specific assessment using sensitive instruments will increase safety and mission completion (23).

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